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Distribution and Causes of Canopy Gaps in White Spruce in the Black Hills

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Spruce mortality, the cause of canopy gaps, is the most serious disorder of white spruce (*Picea glauca* (Moench) Voss) in the Black Hills of South Dakota. Surveys conducted in 1990 and 1991 showed that this disorder is associated with a variety of possible causes, including root disease, stem and root insects, cattle trampling, lightning, flooding, and thin and rocky soils. In this study, Armillaria root disease was the most frequently found causal agent.

Keywords: White spruce, canopy gaps, Armillaria root disease, Black Hills

Introduction

White spruce (*Picea glauca* (Moench) Voss) is the second-most common conifer found in the Black Hills of South Dakota, where it grows primarily in pure stands at high elevations and in canyon bottoms (Hoffman and Alexander 1987). Several disorders have been reported on spruce in this region (Lundquist 1991a), but little is known about the distribution and impact of these disorders. Previously reported diseases (and their causes) include Armillaria root disease (caused by *Armillaria* sp.), broom rust (*Chrysomyxa arctostaphyli* Dietel), cone rust (*Chrysomyxa pirolata* G. Wint.), needle rust (*Chrysomyxa weirii* Jacks), cytospora canker (*Cytospora kunzei* Sacc.), and various wood rots of living trees (*Coniophora puteana* Schumach.:Fr., *Fomitopsis officialis* (Vill.:Fr.) Bondartsev & Singer, *Phaeolus schweinitzii* (Fr.:Fr.) Pat.). During a 1990 survey of conifer tree diseases, a widespread, previously unreported disorder of spruce was noted (Lundquist 1991a). This disorder, referred to as spruce mortality, was identified by canopy gaps following the death of individual or small groups of trees.

Results of a preliminary investigation of the causes and distribution of spruce mortality are presented here.

Methods

This study was conducted in two parts. The first part involved an extensive investigation to determine the distribution of canopy gaps in spruce stands forestwide. We used procedures described by Lundquist (1991b). Briefly, roads that covered most areas of the Black Hills were systematically chosen. We inspected stands within 5 chains on both sides of the roads for canopy gaps resulting from dead and dying spruce trees. In this study, the working definition of canopy gap was "an opening in the canopy created by a standing-dead, stem-broken or uprooted tree(s). Before gap formation, the affected tree's crown was in the main canopy and the tree was at least 5 inches dbh. Regeneration within the gap averaged less than half the height of the living canopy trees along the gap edge." Data were subsequently used to prepare an "isobar" map of gap intensity by connecting townships with similar values for number of gaps per road-mile.

The second part of the study involved an intensive examination of dying spruce trees to determine causes of death. Between 5 and 17 dying and recently dead trees in gaps in each of 29 symptomatic stands (a total of 201 trees) were selected by using a disease distribution map (fig. 1). We examined these trees for clues indicating the cause of death (e.g., mycelial fans or rhizomorphs of *Armillaria* sp., insect galleries, rotted wood, uprooted roots). Selected stands represented most areas of the distributional range of spruce in the Black Hills.

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Results and Discussion

More than 300 road-miles were surveyed. Canopy gaps in spruce stands occur over most of the area surveyed (table 1), although the incidence varies with site (fig. 1). We found canopy gaps in 20 of the 52 townships surveyed at an incidence of 0 to 1.3 gaps per road-mile. Gap distribution extends north to T5N, south to T1S, east to R5E and west to R1E. The distribution map shows two peaks of relatively high incidence in the townships T2NR1E and T3NR3E. Incidence decreases in all directions from these peaks.

Root disease, insects, cattle damage, lightning, shallow soils, and flooding were associated with gaps in spruce stands (table 2). Mycelial fans and rhizomorphs of *Armillaria* sp. were commonly associated with dying spruce, and Armillaria root disease (Shaw and Kile 1991) is probably the major cause of spruce mortality in the Black Hills. *Armillaria* sp. was associated with dying spruce trees in 86% of the stands examined and in 69% of the individual trees. Other agents of mortality capable of causing canopy gaps were considerably less abundant (table 2).

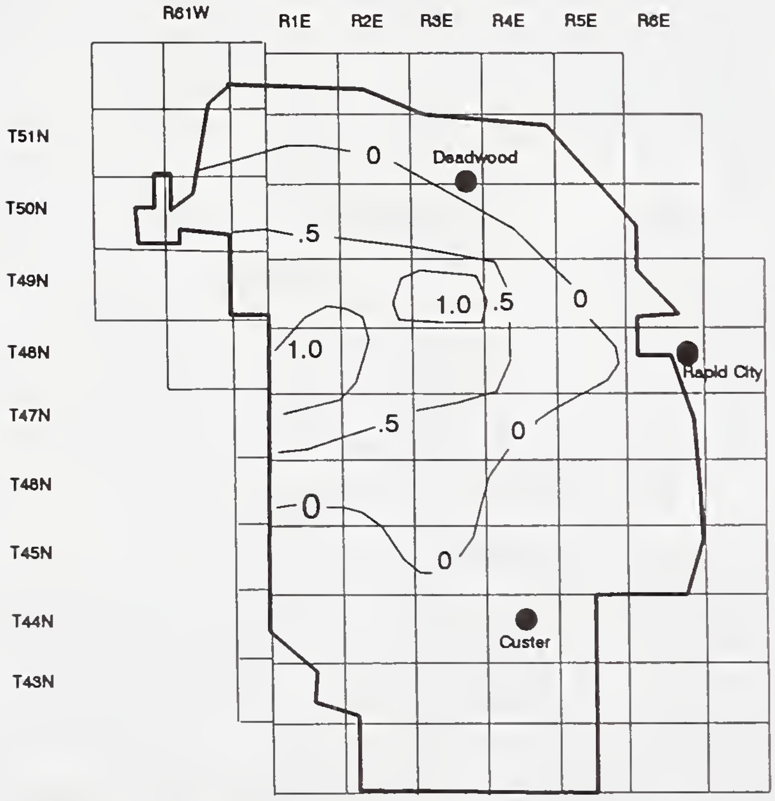

Figure 1. Distribution of canopy gaps in white spruce stands in the Black Hills. Lines connect areas of similar incidence, expressed in number of canopy gaps per road-mile surveyed.

Table 1.—Legal descriptions of sites in the Black Hills where canopy gaps were found in white spruce (*Picea glauca*) stands during surveys in 1990 and 1991.

T4NR1E Sec 16
T4NR2E Sec 19, 24, 36
T3NR1E Sec 4, 10, 36
T3NR2E Sec 9, 26, 27, 33
T3NR3E Sec 6, 8, 20, 26, 27
T3NR4E Sec 18, 19
T2NR1E Sec 13, 14, 23, 24, 26, 27, 32, 34, 35
T2NR2E Sec 4, 6, 10, 11, 12, 15, 21, 23, 29
T2NR3E Sec 7, 18, 24, 26, 27, 32
T2NR4E Sec 25, 28, 30
T2NR5E Sec 1, 9
T1NR1E Sec 5, 8, 22
T1NR2E Sec 5, 8, 15, 16, 20, 21, 26, 27
T1NR3E Sec 21, 32, 36
T1NR4E Sec 4
T1SR1E Sec 6
T1SR2E Sec 4, 11, 26
T1SR3E Sec 14, 27, 28, 31
T2SR4E Sec 19, 33
T2WR4E Sec 5

Table 2.—Incidence (number of trees) and prevalence (number of stands) of causes of spruce mortality. Total number of trees examined = 201. Total number of stands examined = 29.

Cause of spruce mortality	Incidence (# trees)	Prevalence (# stands)
Armillaria root disease	127	25
Armillaria RD + Shallow soil	4	2
Cattle damage	1	1
Insects[1]	33	10
Lightning	3	1
Shallow soil	5	1
Flooding	2	1
Unknown	26	10

[1] *Probably Ips spp.*

Conclusions

Canopy gaps associated with spruce mortality appear to be the most common symptom of spruce disorders in the Black Hills. Undoubtedly, this disorder has a significant impact on the dynamics and successional features of spruce stands and on resources such as wildlife, aesthetics, and water yield, but these relationships have not been studied in this forest.

A variety of agents can cause spruce mortality, and these agents can act in concert or as separate activities in space or time, or both. Results of this study indicate that Armillaria root disease is probably the most common cause of canopy gaps in spruce stands. In many cases, however, specific cause was difficult to determine. Either trees had degraded to a point that evidence of cause was no longer easy to ascertain, or the causal agents were associated with other stress factors, that also could have killed the trees. A more intensive examination of the interactions among various causal agents is needed to: clarify relative importance of each agent; create a better understanding of the dynamics of spruce mortality; and suggest ways in which spruce mortality might be managed to reach the desired future conditions in affected areas.

Literature Cited

Hoffman, G.R.; Alexander, R.R. 1987. Forest vegetation of the Black Hills National Forest of South Dakota and Wyoming: a habitat type classification. Res. Pap. RM-276. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Range and Forest Experiment Station. 48 p.

Lundquist, J.E. 1991a. Tree disease survey of conifers in the Black Hills - 1990. Tech. Report R2-51. Lakewood, CO: U.S. Department of Agriculture, Forest Service, Renewable Resources. 19 p.

Lundquist, J.E. 1991b. Distribution of armillaria root disease in the Black Hills. Tech. Report R2-49. Lakewood, CO: U.S. Department of Agriculture, Forest Service, Renewable Resources. 19 p.

Shaw, C.G. III; and Kile, G.A. 1991. Armillaria root diseases. Agriculture Handbook No. 691. Washington DC: U.S. Department of Agriculture, Forest Service. 233 p.

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